

## And so to fuel (or gasoline or petrol)

Petrol (or gasoline if you're American) is a distilled and refined oil product made up of hydrogen and carbons - a hydrocarbon. A long-chain hydrocarbon to be exact (so don't get it on your skin - its carcinogenic). It's designed to be *relatively* safe to handle, if you're careful. ie. it doesn't spontaneously combust without extreme provocation. When you have a petrol fire, it's not the petrol itself that is burning, it's the vapour, and this is the key to fueling an engine. The carburettor or fuel injectors spray petrol into an air stream. The tiny particles of petrol evaporate into a vapour extremely quickly, and combined in a cloud with the air, it becomes extremely combustible. The smaller the particles from the carburettor jet or fuel injector, the more efficiently the mixture burns.

### Detonation, pre-ignition, pinking, pinging and knocking.

Remember I said petrol doesn't spontaneously combust? Well it can if the conditions are right, and the conditions are extreme heat and pressure - exactly the conditions you find in the combustion chamber. When this happens, it's called detonation or pre-ignition. Diesel engines rely on this process because they don't have a spark plug in the traditional sense of the word. However in petrol engines, when this happens (also known as dieseling), it's a Very Bad Thing. Engines are designed to have the fuel-air mix burn at a fixed point in the cycle, not explode randomly. Whilst it might look like an explosion, if you could film it on a super high-speed camera, you'd see the mixture actually burns up very quickly rather than exploding. Detonation, dieseling or pre-ignition are all terms for what happens when the fuel-air mix spontaneously explodes rather than burning. Normally this happens when the mixture is all fouled up, and the engine is running hot. The temperature and pressure build up too quickly in the combustion chamber and before the piston can reach the top of its travel, the mixture explodes. This explosion tries to counteract the advancing piston and puts an enormous amount of stress on the piston, the cylinder walls and the connecting rod. From the outside of the engine, you'll hear it as a knocking or pinging sound. The precise sound is very hard to describe because every engine sounds slightly different when it happens. But the best way I can describe it is a constant 'toc toc toc' type knocking sound.

### Compression ratio.

The compression ratio of an engine is the measurement of the ratio between the combined volume of a cylinder and a combustion chamber when the piston is at the bottom of its stroke, and the same volume when it's at the top of its stroke. The higher the compression ratio, the more mechanical energy an engine can squeeze from its air-fuel mixture. Similarly, the higher the compression ratio, the greater the likelihood of detonation.

## Octane ratings - how to stop detonation

So you know that a fuel-air mix, given the right conditions, *can* spontaneously combust. In order to control this property, all petrols have chemicals mixed in with them to control how quickly the fuel burns. This is known as the octane rating of the fuel. The higher the rating, the slower and more controlled the fuel burns. Put on the geek-shades for a moment and I'll explain octane in more depth. If you don't like being blinded by science, skip down a few paragraphs. For the rest of you, octane is measured relative to a mixture of isooctane (2,2,4-trimethylpentane, an isomer of octane) and n-heptane. An 87-octane gasoline has the same knock resistance as a mixture of 87% isooctane and 13% n-heptane. The octane value of a fuel used to be controlled by the amount of tetraethyl lead in it, but in the 70s and 80s when it became apparent that lead was pretty harmful, lead-free petrol appeared and other substances were introduced to control octane instead.

### Measuring octane - RON, MON and the difference between America and the rest of the world.

Just so you know, the octane number is actually an imprecise measure of the maximum compression ratio at which a particular fuel can be burned in an engine without detonation. There

are actually two numbers - RON (Research octane number) and MON (Motor Octane Number). The RON simulates fuel performance under low severity engine operation. The MON simulates more severe operation that might be incurred at high speed or high load and can be as much as 10 points lower than the RON. In Europe, what you'll see on the petrol pumps is the RON. However, in America, what you'll see on the petrol pump is usually the "mean" octane number - notified as (R+M)/2 - the average of both the RON and MON. This is why there is an apparent discrepancy between the octane values of petrol in America versus the rest of the world. Euro95 unleaded in Europe is 95 octane but it's the equivalent of American (R+M)/2 89 octane. In America, low altitude petrol stations typically sell three grades of petrol with octane ratings of 87, 89 and 91. High altitude stations typically also sell three grades, but with lower values - 85, 87 and 89.

## What factors affect detonation?

There's a bunch of things that can affect how likely an engine is to have detonation problems. The common ones are ambient air temperature, humidity, altitude, your engine's ability to stay cool (ie. the cooling system) and spark timing. Fortunately, nowadays the engine management system of modern cars can compensate for almost all of these by advancing and retarding the ignition timing. This is where the computer slightly adjusts the point in the ignition cycle at which the spark is generated at the spark plug. With older engines that used mechanical points to send current to the spark plugs, adjusting the timing was a manual affair that involved adjusting the distributor cap orientation.

Knock sensors. Most modern cars have knock sensors screwed into the engine at multiple places. These actually detect the vibration or shock caused by detonation (rather than trying to detect the sound) and can signal the engine management system to change the ignition timing to reduce or eliminate the problem.

## Octane and altitude

The higher the altitude above sea level, the lower the octane requirement. As a general rule of thumb, for every 300m or 1000ft above sea level, the RON value can go down by about 0.5. For example an 85 octane fuel in Denver will have about the same characteristics as an 87 octane fuel on the coast in Los Angeles. As a practical example of this, I currently live in Salt Lake City which is at around 4,200ft. We travel to Las Vegas from time to time which is at around 2,000ft. Our Subaru has a minimum octane requirement of 89 at sea level - so about 87 where we live. Last time we drove to Vegas, the petrol station we stopped at had run out of 'premium' products so we had to fill up with 85 octane. This, combined with the drop in altitude caused the 'check engine' light to come on because we'd effectively taken the engine from 87 octane at altitude to the equivalent of 83 octane at altitude - way below the minimum required by our car.

## Octane and power

It's a common misconception amongst car enthusiasts that higher octane = more power. This is simply not true. The myth arose because of sportier vehicles requiring higher octane fuels. Without understanding why, a certain section of the car subculture decided that this was because higher octane petrol meant higher power. The reality of the situation is a little different. Power is limited by the maximum amount of fuel-air mixture that can be jammed into the combustion chamber. Because high performance engines operate with high compression ratios they are more likely to suffer from detonation and so to compensate, they need a higher octane fuel to control the burn. So yes, sports cars do need high octane fuel, but it's not because the octane rating is somehow giving more power. It's because it's required *because the engine develops more power because of its design.* There is a direct correlation between the compression ratio of an engine and its fuel octane requirements. The following table is a rough guide to octane values per engine compression ratio for a carburettor engine without engine management. For modern fuel-injected cars with advanced engine management systems, these values are lowered by about 5 to 7 points.

Compression ratio   Octane

## COMPRESSION      OCTANE

5:1	72
6:1	81
7:1	87
8:1	92
9:1	96
10:1	100
11:1	104
12:1	108

### Octane and gas mileage

Here's a good question : can octane affect gas mileage. The short answer is absolutely, yes it can, but not for the reasons you might think. The octane value of a fuel itself has nothing to do with how much potential energy the fuel has, or how cleanly or efficiently it burns. All it does is control the burn. However, if you're running with a petrol that isn't the octane rating recommended for your car, you could lose gas mileage. Why? Lets say your manufacturers handbook recommends that you run 87 octane fuel in your car but you fill it with 85 instead, trying to save some money on filling up. Your car will still work just fine because the engine management system will be detecting knock and retarding the ignition timing to compensate. And that's the key. By changing the ignition timing, you could be losing efficiency in the engine, which could translate into worse gas mileage. Again as a practical example, my little tale above about our trip to Vegas on low octane gas. (Whether you want to believe some bloke on the internet or not is up to you). On the low octane gas on the trip down, we could barely get 23.5mpg out of the Subaru. Once I was able to fill it up again with premium at the recommended octane rating, we got 27.9mpg on the way back. A difference of 4.4mpg over 450 miles of driving. Doing the maths, you can figure out that by skimping on the price during fill-up, you may save a little money right there and then, but it costs in the long term because you're going to be filling up more often to do the same mileage. My advice? Do what the handbook tells you. After all it's in the manufacturers better interests that you get the most performance out of your car as you can - they don't want you badmouthing them, and in this day and age of instant internet gratification, you can bad-mouth a large company very quickly and get a lot of publicity.

## Doing Your Own Service Work

### ⚠ CAUTION:

You can be injured and your vehicle could be damaged if you try to do service work on a vehicle without knowing enough about it.

- Be sure you have sufficient knowledge, experience, the proper replacement parts, and tools before you attempt any vehicle maintenance task.
- Be sure to use the proper nuts, bolts, and other fasteners. English and metric fasteners can be easily confused. If you use the wrong fasteners, parts can later break or fall off. You could be hurt.

You want to do some of your own service work. You will want to use the proper service manual. It tells you much more about how to service your vehicle than this manual can. To order the proper service manual, see *Service Publications Ordering Information* on page 7-15.

Your vehicle has an airbag system. Before attempting to do your own service work, see *Servicing Your Airbag-Equipped Vehicle* on page 1-65.

You should keep a record with all parts receipts and list the mileage and the date of any service work you perform. See *Maintenance Record* on page 6-14.

## Adding Equipment to the Outside of Your Vehicle

Things you might add to the outside of your vehicle can affect the airflow around it. This may cause wind noise and affect windshield washer performance. Check with your dealer before adding equipment to the outside of your vehicle.

## Fuel

The 8th digit of your vehicle identification number (VIN) shows the code letter or number that identifies your engine. You will find the VIN at the top left of the instrument panel. See *Vehicle Identification Number (VIN)* on page 5-92.

## Gasoline Octane

If your vehicle has the 3.8L V6 engine (VIN Code 2), use regular unleaded gasoline with a posted octane rating of 87 or higher. If the octane rating is less than 87, you may notice an audible knocking noise when you drive, commonly referred to as spark knock. If this occurs, use a gasoline rated at 87 octane or higher as soon as possible. If you are using gasoline rated at 87 octane or higher and you hear heavy knocking, your engine needs service.

If your vehicle has the 3.6L V6 engine (VIN Code 7), use regular unleaded gasoline with a posted octane rating of 87 or higher. For best performance or trailer towing, you may choose to use middle grade 89 octane unleaded gasoline. If the octane rating is less than 87, you may notice an audible knocking noise when you drive, commonly referred to as spark knock. If this occurs, use a gasoline rated at 87 octane or higher as soon as possible. If you are using gasoline rated at 87 octane or higher and you hear heavy knocking, your engine needs service.

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## Your Own Service Work

If you do some of your own service work, you'll find the proper service manual. It tells you much about how to service your vehicle than this manual can. For the proper service manual, see "Service Manuals" in the Index.

If you have an air bag system. Before attempting to do any service work, see "Servicing Your Air Bagged Vehicle" in the Index.

If you want to keep a record with all parts receipts and list the date of any service work you have, see "Maintenance Record" in the Index.

1999 CHEVROLET

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- Be sure to use the proper nuts, bolts and other fasteners. "English" and "metric" fasteners can be easily confused. If you use the wrong fasteners, parts can later break or fall off. You could be hurt.

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## Fuel (Gasoline Engine)

If your vehicle has a diesel engine, see "Diesel Fuel Requirements and Fuel System" in the Diesel Engine Supplement. For vehicles with gasoline engines, please read this.

Use regular unleaded gasoline rated at 87 octane or higher. It is recommended that the gasoline meet specifications which have been developed by the American Automobile Manufacturers Association (AAMA) and endorsed by the Canadian Motor Vehicle Manufacturers Association for better vehicle performance and engine protection. Gasolines meeting the AAMA specification could provide improved drivability and emission control system performance compared to other gasolines. For more information, write to: American Automobile Manufacturers Association, 7430 Second Ave, Suite 300, Detroit MI 48202.

Be sure the posted octane is at least 87. If the octane is less than 87, you may get a heavy knocking noise when you drive. If it's bad enough, it can damage your engine.

If you're using fuel rated at 87 octane or higher and you hear heavy knocking, your engine needs service. But don't worry if you hear a little pinging noise when you're accelerating or driving up a hill. That's normal, and you don't have to buy a higher octane fuel to get rid of pinging. It's the heavy, constant knock that means you have a problem.